



RP 12-6

ELECTRICAL SYSTEMS AND INSTALLATIONS - HIGH VOLTAGE SWITCHGEAR

November 1994

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SCOPE AND PURPOSE This document supplements international standards and contains recommendations for the selection and use of High Voltage Switchgear. Its purpose is to ensure the provision of fit for purpose equipment at minimum cost/complexity											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Recommended Practice provides guidance additional to that available in national and international documents and draws the designers attention to the peripheral issues affecting the design of a high voltage switchgear installation.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

Generally updated and re-formatted with references updated to include IEC standards.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

BP Group RP 12 series of documents specify BP general requirements for electrical systems, equipment, materials and installations.

This document (BP Group RP 12-6) specifies requirements for the selection and application of high-voltage switchgear. This document may also be used for applications such as neutral earthing switchgear and autotransformer motor starter star point earthing switchgear.

2. DESIGN REQUIREMENTS

2.1 Switchgear Type and Specification

2.1.1 High-voltage switchgear for indoor installations shall comply with BP Group [GS 112-9](#).

This document does not give detailed guidance for the use of outdoor high-voltage switchgear as this type of equipment is rarely used within the Oil Industry. When an application arises giving a cost benefit then standards local to the installation site should be adopted.

2.1.2 The following factors shall be taken into account when selecting the type of high-voltage switchgear:-

(i) Economic considerations.

This consideration should not only include the initial purchase cost but any cost penalties associated with excessive weight or size, (important for offshore installation in particular). Whole life costs should form a part of the evaluation.

(ii) The switchgear shall be of an adequate fault rating with due consideration for all anticipated expansions. For the method of determining fault ratings see BP Group [RP 12-3](#).

(iii) The switchgear shall be suitable for interrupting currents which include the anticipated d.c. levels.

Note that the d.c. content of current waveform at any time following fault application is affected by the X/R ratio of the circuit to the point of fault. Switchgear tested in accordance with [IEC 56](#) have a relationship between 'make' and 'break' current which assumes a system X/R ratio of 14. Where the system X/R ratio exceeds this value it may be necessary to undertake supplementary testing to prove equipment is adequate for the duty.



(iv) The switchgear should be of a type for which there is an acceptable technical and commercial 'back-up' service available in the locality.

(v) The desired fault clearance times.

2.1.3 Circuit breakers should not be used for motor switching unless the duty is in excess of the available rating for contactor control equipment.

Contactor control equipment will invariably offer a more compact assembly at lower cost.

2.1.4 Switchgear should preferably be of the vacuum or SF₆ type. However, where technical or economic advantages are offered by other types they may be proposed as an alternative.

These types of switchgear have generally been developed in preference to other types of switchgear due to their compact size and low cost. It is unlikely that other types of construction will be attractive except in the case of extension to existing facilities.

2.1.5 The type and nature of switchgear should form part of the consideration associated with the fire protection/detection requirements of BP Group [RP 24-1](#) and BP Group [RP 24-2](#).

2.2 Operating Mechanisms

2.2.1 For circuit breakers, power driven mechanisms which do not require manual assistance shall be used.

Mechanisms requiring manual assistance should not be used as rated short circuit making and breaking currents are indeterminate due to the uncontrolled nature of their operation, resulting in the possibility of circuit breakers being operated outside their capability.

2.2.2 Isolators which are operated live shall be of the assisted type.

Similarly as the commentary for 2.2.1, isolators without assisted mechanisms could exceed their making and breaking capability.

2.2.3 Direct Current solenoid operated circuit breakers shall have the required d.c. voltage stated on the certificate of rating and it is vital that this is maintained for those breakers with an 'enhanced making' capability. Specific attention shall be given to the d.c. power supply specification.

A breaker with an enhanced making capacity has a modified closing mechanism which ensures a short closing time. It is therefore essential that this time is not extended by operation outside the design values.



2.3 Control

2.3.1 For additional control requirements including circuit breakers and starters, this section should be read in conjunction with BP Group [RP 12-4](#).

2.3.2 All circuit breakers and contactors shall have a manual trip facility local to the panel. Local operation of circuit breakers shall be possible when being used for the purpose of earthing the appropriate side, e.g. earthing the circuit side of outgoing feeders and motor starters and the incoming side of incoming feeders, etc.

2.3.3 All remote controlled circuit breakers and contactors shall have the closing device local to the panel either omitted or made inoperable when the circuit breaker or contactor is in the normal operating position.

A local closing device may be useful for maintenance purposes when the circuit breaker or contactor is in the test position but its use would be undesirable in the operating position where this may contravene the operation philosophy. It is normal operation philosophy for safety reasons to only operate a HV circuit breaker from a position away from the switchboard. This is particularly desirable when a switchboard has not been tested to demonstrate its ability to contain internal arcing faults.

2.3.4 Circuit breakers with power assisted closing, and withdrawable type contactors, should be provided with a means of operational testing when in the test, or part withdrawn isolated position. The tripping device local to the panel shall be operable in the test position as shall the closing device local to the panel if fitted. In the test position all other remote and automatic control circuits shall be inoperable.

This facility should allow for the testing of the circuit breaker or contractor without unnecessary or unexpected operation.

2.3.5 Circuit breaker intertripping between low voltage and high voltage switchgear should be provided in accordance with the recommendations of BP Group [RP 12-4](#).

There are many methods of implementing an intertripping scheme. The most common schemes are based on 4 wire designs with intertripping from high-voltage to low-voltage, and low-voltage to high-voltage ends, each having electrically separate circuits utilising two wires each.

2.3.6 Circuit breakers shall be controlled normally from within the sub-station, but remotely from the switchpanel.

See commentary for 2.3.3.



- 2.3.7 Control of a motor starter shall be from a control station adjacent to the motor or control panel in a location remote from both the motor and starter equipment.

See commentary for 2.3.3, control of a motor would not be from the switchgear.

- 2.3.8 Any emergency 'stop' control for motor starters should form part of the primary stop control circuit and the use of interposing relays should be avoided. If interposing relays and/or the introduction of an auxiliary power supply is unavoidable then the latter shall be derived from a secure source.

The release of any emergency 'stop' control shall not cause re-energisation of the equipment concerned.

This requirement is primarily related to drives functioning on automatic control, the restart inhibit can be achieved either at the switchgear or with the drive control logic.

- 2.3.9 For motor contactor units directly controlled via control circuits over 600 m long, the following alternatives should be considered:-

- (i) The use of interposing relays.

Providing remote control circuits do not exceed 600 m of 2.5 mm² cable the voltage drop in the remote control circuit (when a contactor closes) should not exceed 5%.

- (ii) 110 V d.c. control.

Very long lengths of control cable, typically in excess of 1500m, will have an appreciable capacitance which may cause relays to remain energised incorrectly. The use of 110 V d.c. will overcome this problem.

2.4 Trip Circuit Supervision

- 2.4.1 Trip circuit supervision should be considered a standard requirement for circuit breakers supplying high value capital plant. The supply should be monitored whether the breaker is open or closed and the continuity of a maximum amount of the looped wiring to protection relay contacts, and internal and external tripping contacts should be monitored.

A distinction between trip circuit supervision and trip supply supervision should be understood, where in addition to ensuring the presence of a trip supply, trip circuit supervision also monitors the continuity of the circuit.

Trip circuit supervision is only applicable to shunt tripped devices.

Trip circuit supervision does not cover all the faults which could prevent a breaker from tripping. A mechanical failure could prevent a trip, and therefore 'sticky breaker' protection may often be appropriate, either instead of, or possibly as well as trip circuit supervision. 'Sticky breaker' protection would provide a back up which would trip upstream circuits automatically if the actual circuit is not tripped.

2.5 Protection

- 2.5.1 Protection shall be provided in accordance with the requirements of BP Group [RP 12-4](#).

2.6 Earthing

- 2.6.1 Integral facilities should be provided for earthing the incoming side of each incoming supply feeder, the circuit side of each outgoing feeder and motor starter, and for busbar earthing of each section of busbar via at least one panel.

The final connection to earth should preferably be made through a circuit breaker. However, other methods are acceptable provided they are fully fault tested.

- 2.6.2 The earthing of single core cables with a metallic sheath and/or armour requires particular care.

Single core cables entering a gland plate should have provision to reduce the effects of eddy currents flowing in the gland plate.

Single core cables with a metallic sheath/armour may require to be de-rated if they are earthed at both ends due to circulating currents in the sheath/armour.

If the de-rating associated with earthing at both ends is unacceptable, the sheath/armour should be earthed at one end only, the other ends being insulated from earth and each other. The earthed end should always be at the 'field' end as the insulation integrity is better maintained in an 'indoor' environment and additionally, if the field end is in a hazardous area, the conditions for a safe installation are easily met if the sheath/armour is earthed.

More detailed guidance on this topic is given in BP Group [RP 12-16](#).

2.7 Motor Re-acceleration

- 2.7.1 For schemes involving the automatic re-acceleration of motors, proposals should be developed for the automatic reclosure of contactors and circuit breakers from studies as described in BP Group [RP 12-3](#).

Re-acceleration schemes will provide either a 'ride-through' capability where the circuit breaker or contactor remains closed for the duration of a power system disturbance or a 're-start' capability where dedicated logic will automatically restart a stopping or stopped drive (or number of drives) following a disturbance.

The choice of scheme will depend on the criticality of the drive and the capability of the power system.

A number of factors need to be considered:-

The motor residual voltage which could cause damaging transient torques if the supply is reconnected out of phase with a large residual voltage.

The ability of the power system to support the starting current of a number of motors. If the power system cannot re-accelerate all the motors on the system simultaneously then motors should be arranged in groups, and time delays introduced so each group achieves full speed before the next group is started. An under voltage detection with an appropriate time delay will ensure that no attempt will be made to re-accelerate drives if the undervoltage persists for an unacceptably long time.

Care should be exercised as a number of drives will have a 'standby' which will attempt to start from for instance a process condition (low flow, low pressure etc.) due to the duty drive stopping. It should be ensured that a conflict in control strategy does not arise.

2.8 Interlocks

2.8.1 Mechanical interlocking should be provided on switchgear to achieve the following:-

- (i) Prevention of access to live parts. Safe and adequate provision should nevertheless be made to enable access for tests.

The ingress protection of the switchgear in its normal operating condition (typically IP3X or better) will ensure a safe installation. However, the equipment could be operated in such a manner that the ingress protection is reduced (i.e. circuit breakers withdrawn, voltage transformers withdrawn) and free access is given to live parts. Devices should then be installed (typically shutters) such that the ingress protection is maintained under all conditions.

- (ii) Prevention of operation of isolators or earthing devices until necessary switchgear conditions are satisfied.

It shall be impossible to operate such devices under conditions other than those for which they are intended. For example an isolator should only be operated when the associated circuit breaker, switch or contactor is in the open position. Similarly it should be ensured that all possible incoming feeds to a point of earth application are isolated before an earth application is possible.

- (iii) Prevention of operation of the main circuit device until necessary switchgear conditions are satisfied.

The operation of a circuit breaker, switch or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position.

- 2.8.2 Where circuits include electrical interlocks the design should be as far as possible 'fail safe'.

The failure of electrical components (such as relays and switches) in their recognised failure modes shall ensure that there is no reduction in the safe operation of the equipment. This would normally mean that a failure would result in the circuit becoming de-energised if it was originally energised, or that energisation would be prevented if it was not energised already, or that an earth could not be applied.

2.9 Control of Capacitors

- 2.9.1 Capacitors provided for power factor correction should comply with the requirements of [IEC 871-1](#).

Specific attention should be given to the notes contained in [IEC 871-1](#) regarding discharge devices for capacitors.

2.10 Alarms and Indications

- 2.10.1 Alarms and indicators shall be provided in accordance with the requirements of BP Group [RP 12-4](#).

2.11 Ancillary Equipment

- 2.11.1 Ancillary equipment shall be provided and accommodated as required and may include:-

- (i) Batteries with associated charging and control equipment.
- (ii) Direct current supply, distribution and control switchgear and systems.
- (iii) Alternating current auxiliary supply, distribution and control switchgear and systems.

- 2.11.2 All necessary equipment shall be included for the operation, maintenance and handling of the installed equipment, e.g. switch trucks, special tools, testing and earthing equipment.

3. SWITCHGEAR INSTALLATION

3.1 Access

Adequate clearance should be provided around the switchgear for maintenance, operation, access and anticipated extensions.

Local regulations will determine the minimum clearances allowed around a switchboard. In the absence of such regulations a 1 m minimum clearance in front



of switchboards has been found to be practical. This may need to be increased when withdrawable equipment is fitted, and in this event a minimum clearance of 0.4 m should be allowed when the equipment is fully withdrawn. A minimum clearance of 0.6 m should be allowed at the rear of switchboards, and this dimension is appropriate for the ends, due consideration being given to any requirement for future extension of the switchboard at either end.

The equipment manufacturer should always be consulted for recommended clearances.



DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSE's Introductory Volume.

high-voltage: a system whose voltage exceeds 1000 V a.c. or 1500 V d.c. between conductors

Abbreviations

BS	British Standard
IEC	International Electrotechnical Commission
SF ₆	Sulphur Hexafluoride
d.c.	direct current
a.c.	alternating current
X/R	Reactance/Resistance



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

International Codes or Standards

IEC 56	High-voltage alternating-current circuit breakers
IEC 871-1	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V

BP Group Documents

BP Group RP 12-3	Power System Design (replaces BP CP 17 Part 3)
BP Group RP 12-4	Power System Protection and Control (replaces BP CP 17 Part 4)
BP Group RP 12-16	Electrical Systems and Installations Earthing and Bonding (replaces CP 17 Part 16)
BP Group RP 24-1	Active Fire Protection (replaces CP 15/CP 16)
BP Group RP 24-2	Passive Fire Protection (replaces CP 15/CP 16)
BP Group GS 112-9	High Voltage Switchgear and Controlgear (replaces Std 225)